Fire Hazard Analysis
200-MeV Linear Accelerator (LINAC)
Building 930, 930A, 930B

Brookhaven National Laboratory

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Date of Last Survey: None on record
Date of Report: August, 2007

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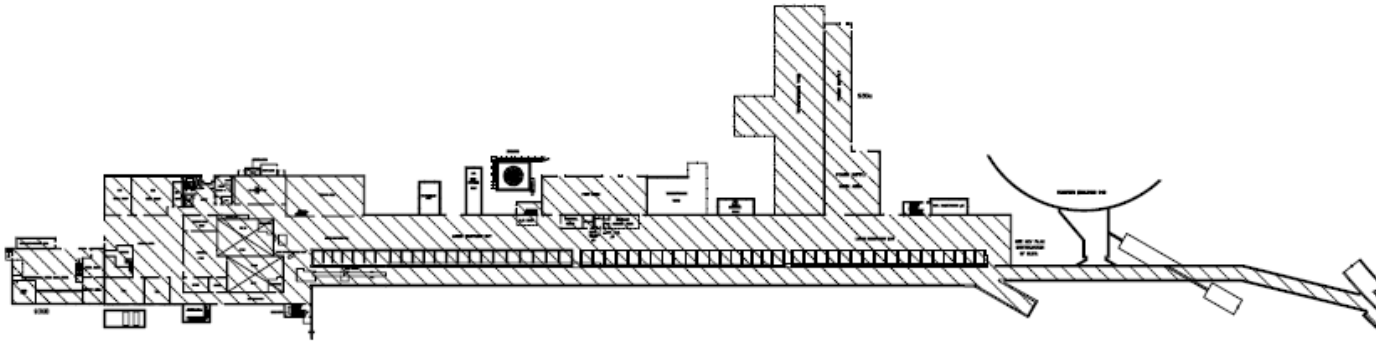

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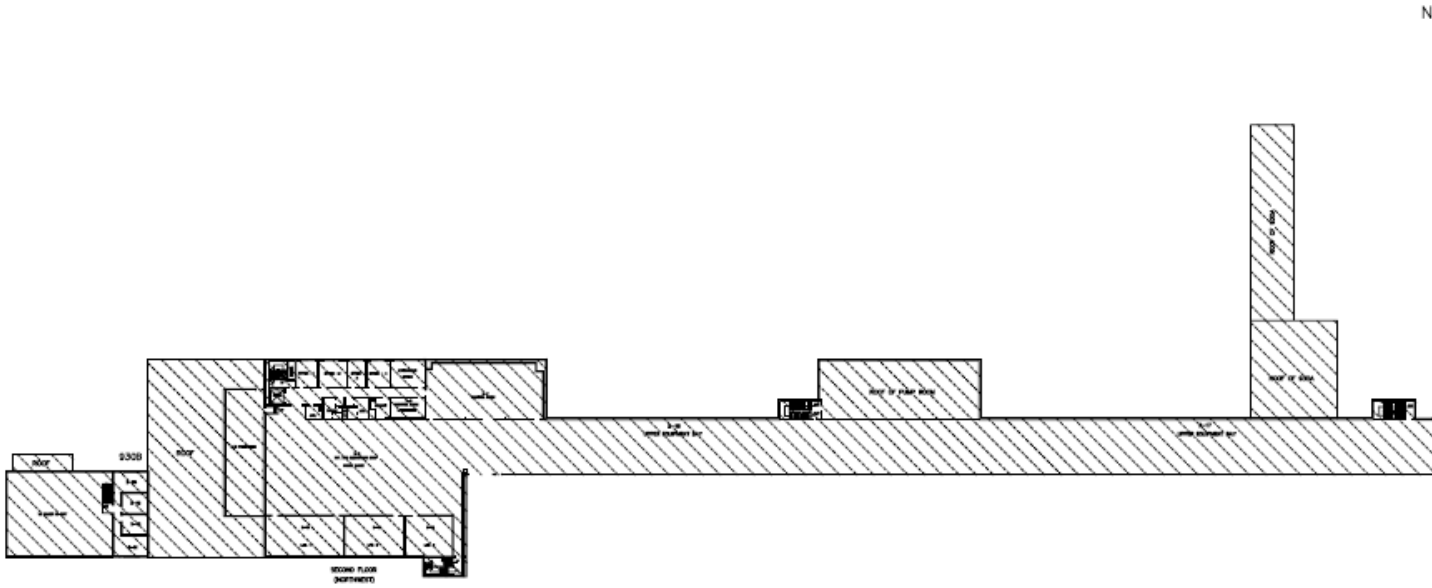

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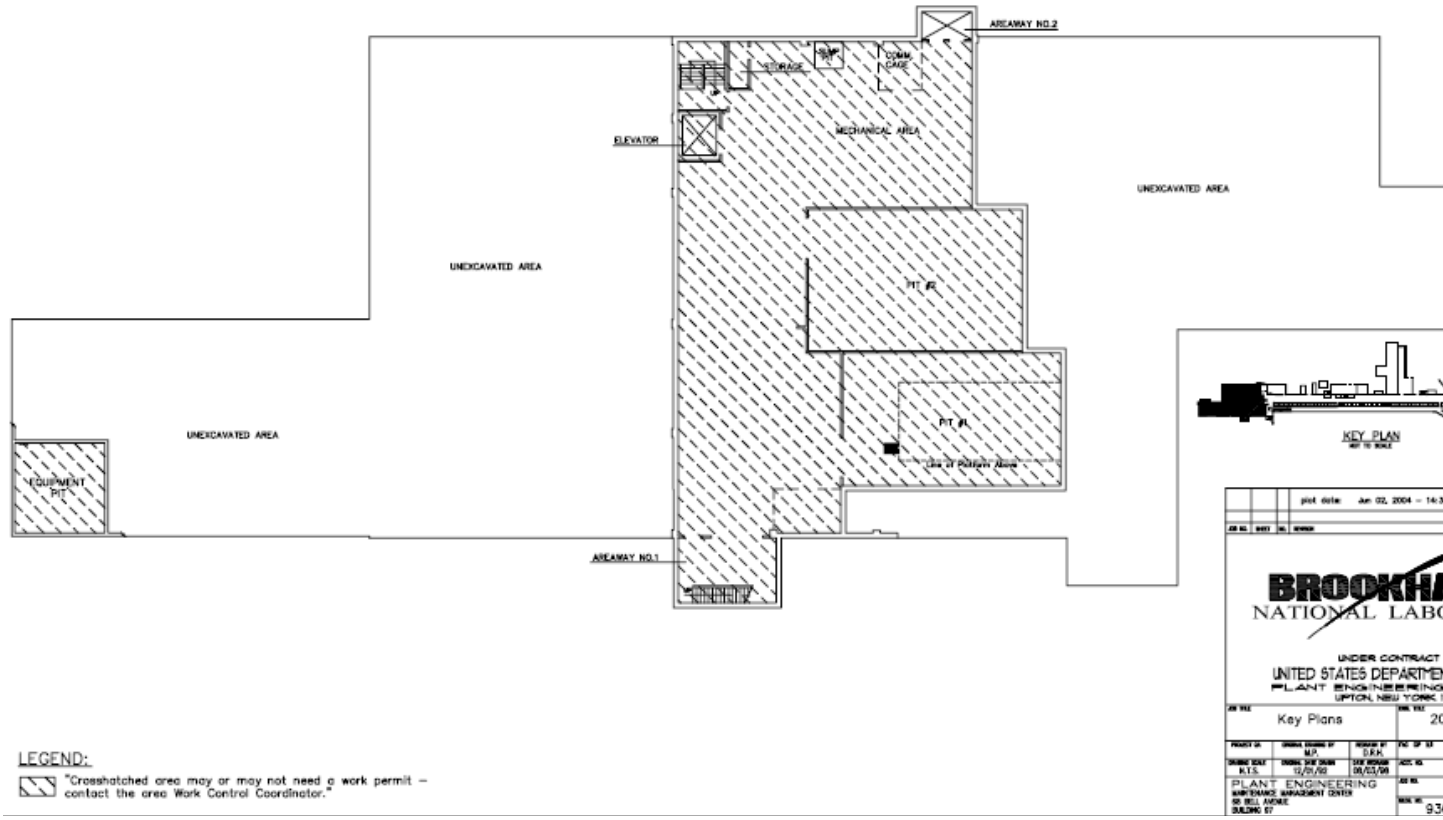
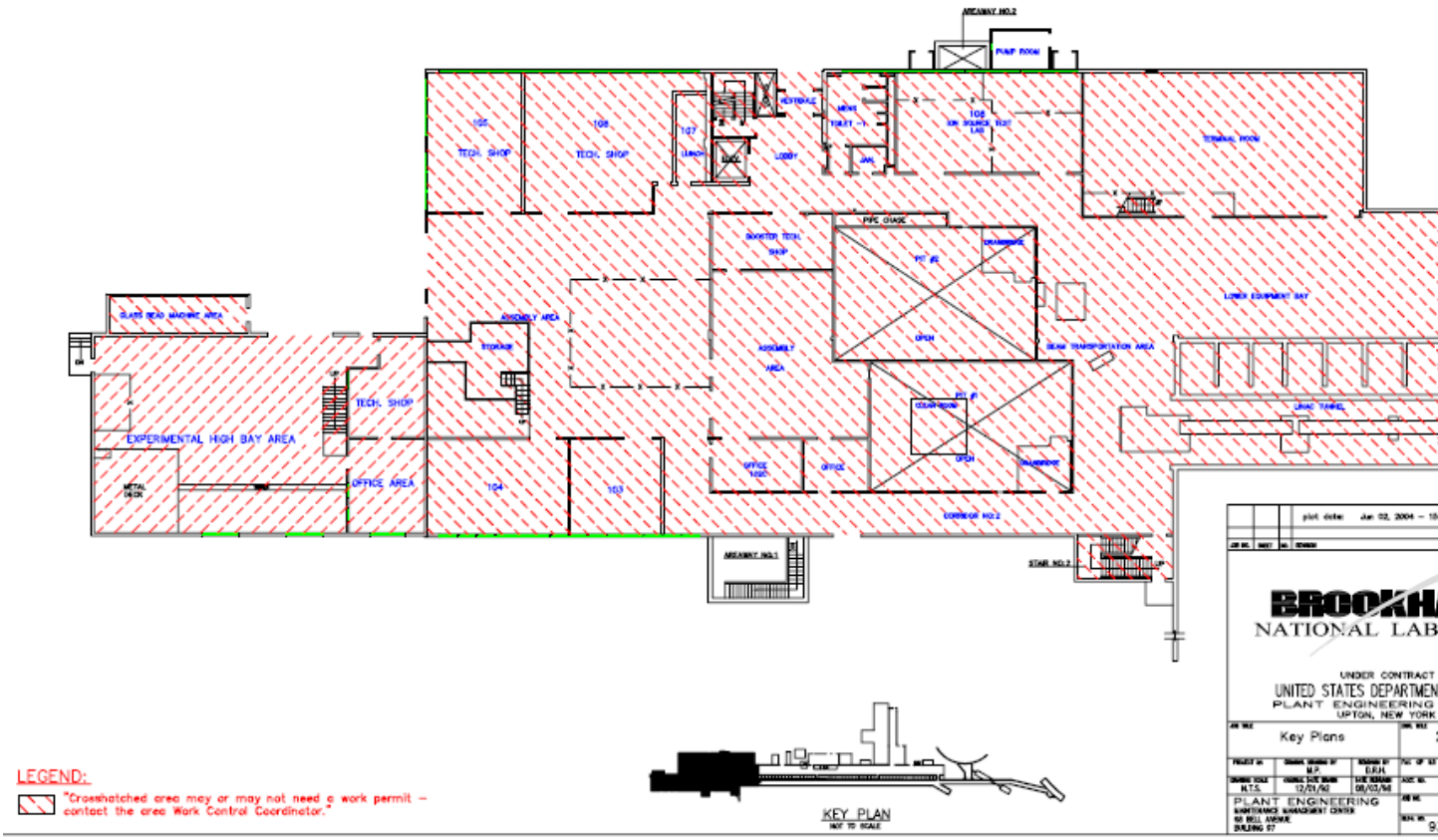
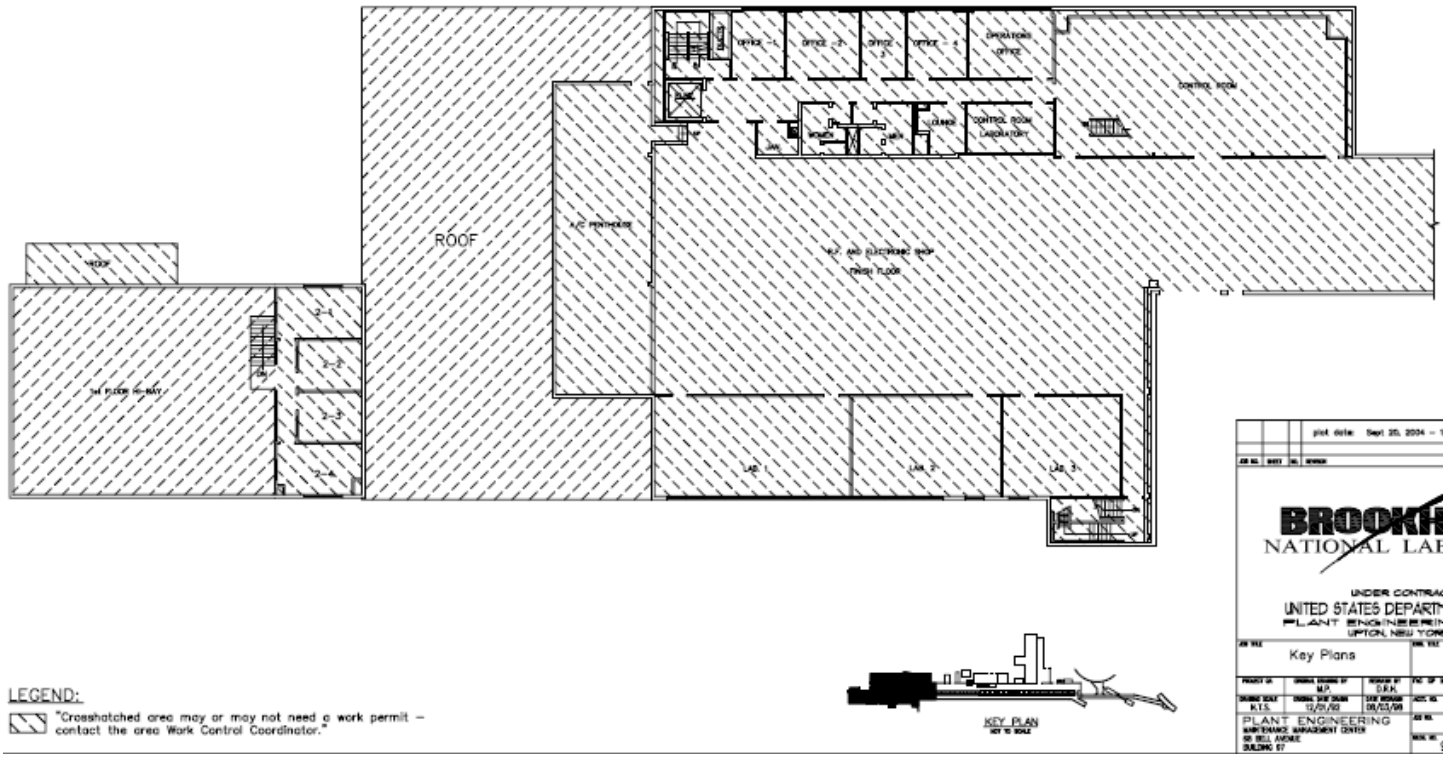
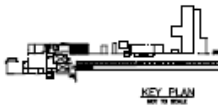
Key Plans

PLANT ENGINEERING









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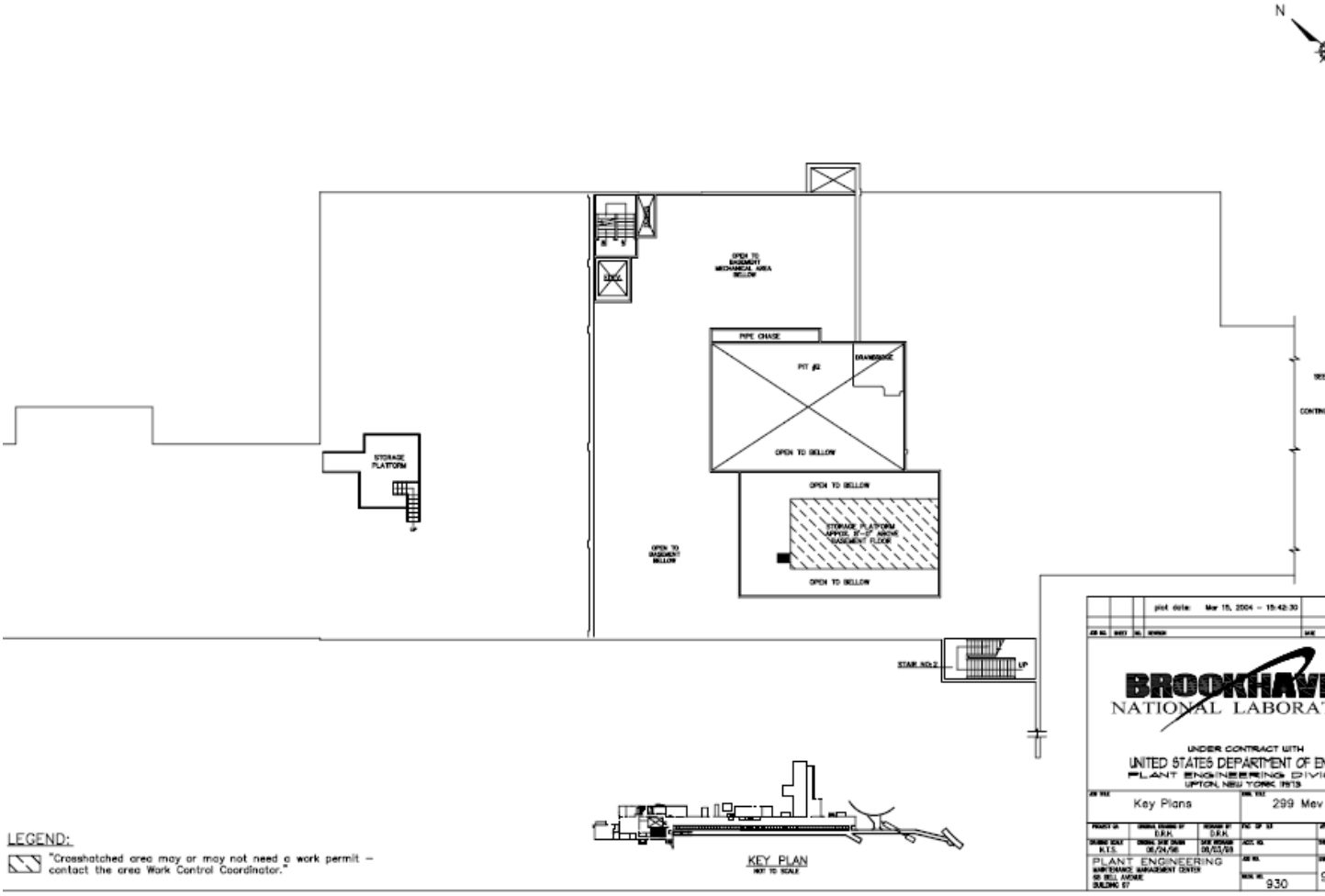
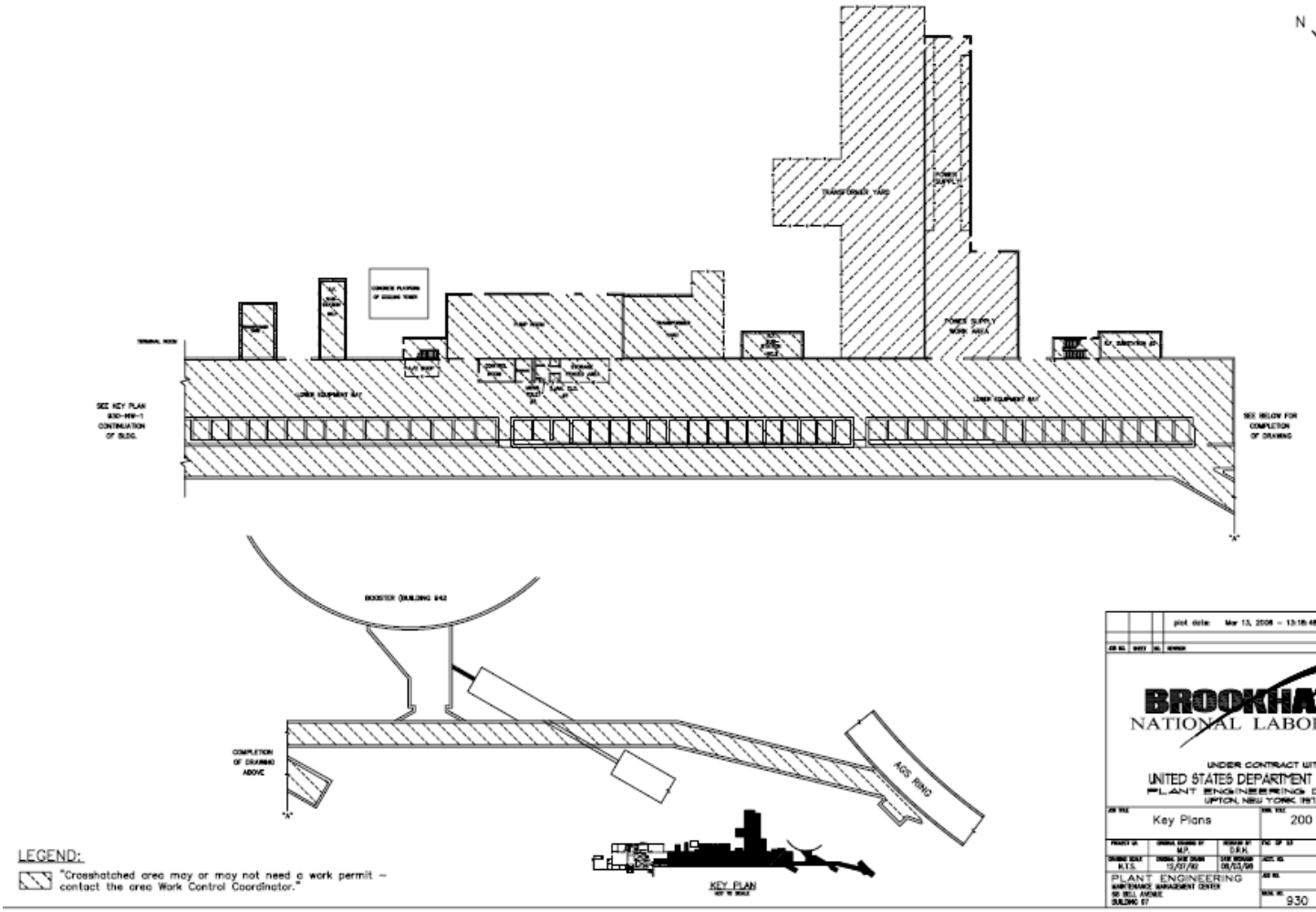
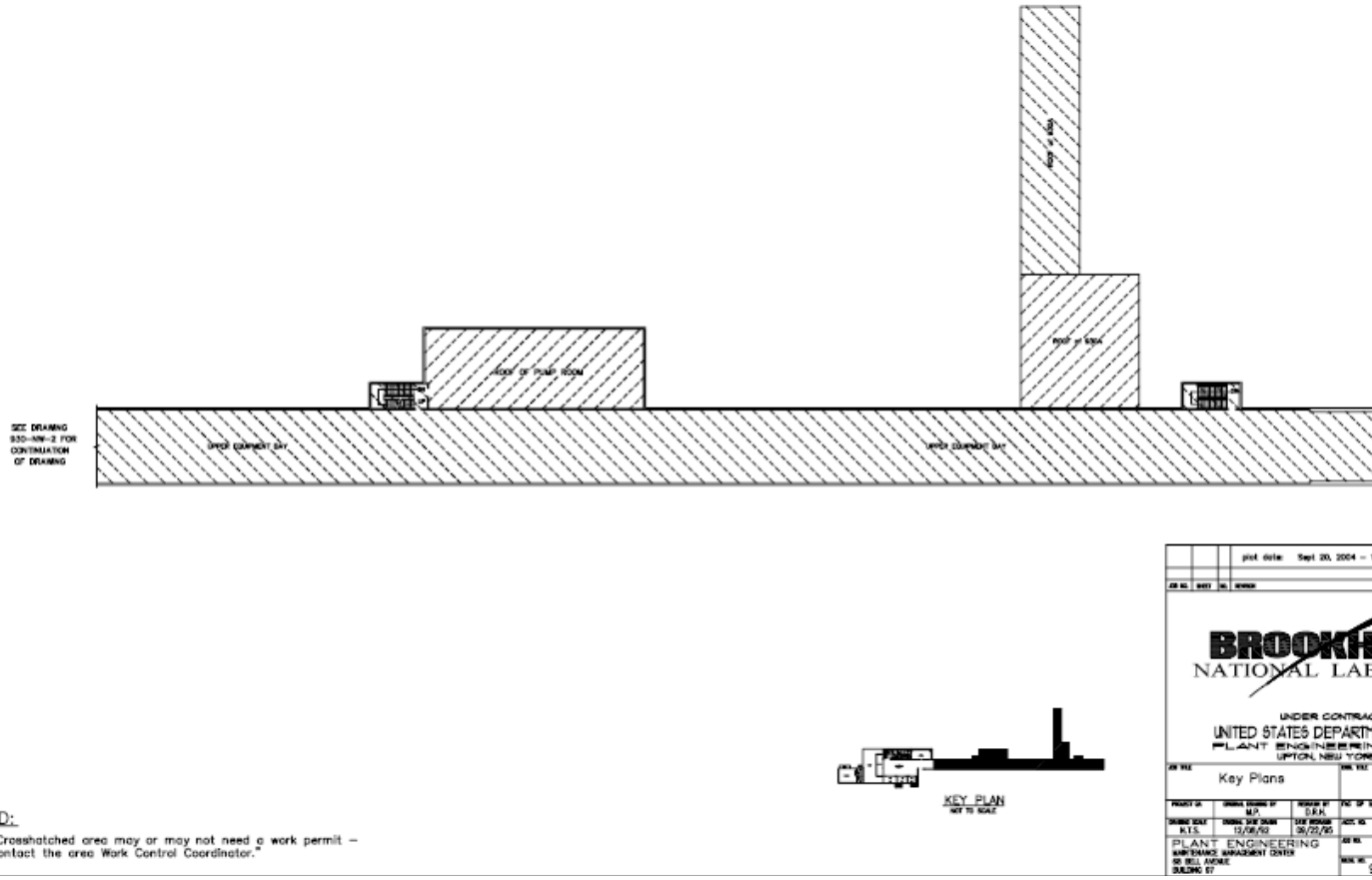






1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for Building 930, the 200-MeV LINAC at Brookhaven National Laboratory (BNL), Upton, NY. This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 930 to ascertain whether the facility meets the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose Building 930 and (2) that are inherent in the building or operations. The adequacy of the fire safety features in the building and the degree of compliance of the facility with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the building and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment values were calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 1.3, Findings and Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. Hazard Severity. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

   a. Category I. May cause death, permanent total disability, or loss of a facility/asset.

   b. Category II. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

   c. Category III. May cause minor injury, occupational illness, or property damage.

   d. Category IV. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected

populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	Mishap Probability			
	A	B	C	D
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

The 200-MeV LINAC was designed and built in the late 1960's as a major upgrade to the AGS complex. The LINAC's purpose is to provide accelerated high-intensity protons for use at AGS, polarized protons at RHIC, and high-intensity protons at a Medical Department facility known as the Brookhaven LINAC Isotope Producer (BLIP). The basic components of the LINAC include ion sources, a radiofrequency quadrupole pre-injector and nine accelerator radiofrequency cavities spanning the length of a 460-foot tunnel. The LINAC is capable of producing up to a 35-milliampere proton beam at energies up to 200 MeV for injection into the Booster or for the activation of targets at the Brookhaven LINAC Isotope Producer (BLIP).

The LINAC, was designed and built in the late 1960's and is 103,647 square feet.

The descriptions are based on field surveys, a review of the as-built documents, and discussions with BNL staff. This assessment and FHA demonstrates the achievement of a reasonable and equivalent level of fire safety that meets DOE improved risk objectives.

Overview of the BNL

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in Building 930, Linear Accelerator (LINAC). The RHIC facility consists of a beam injection system, two superconducting magnet beam storage rings, six experimental halls, and a number of support buildings. Accelerated protons, deuterons or heavy ions in counter-rotating beams, each in separate rings, may be brought into collision at five different locations where experiments are conducted. The particle cascade produced by the colliding beams is recorded by various instruments to study nuclear phenomena in detail.

This FHA includes an analysis of the fire and life safety features of the facility to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that Building 930 does not comply with DOE Order 420.1 Fire Protection objectives.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

Finding: Pit # 2 does not have any fire protection and is currently being used for storage.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-930-01: Automatic sprinkler protection should be provided in Pit #2. The system shall be designed and installed in accordance with NFPA 13 requirements. The sprinklers will be designed for ordinary hazard spacing and connected to the west side sprinkler zone system piping. Pipe sizing shall be hydraulically designed to provide a minimum density of 0.15 gallons per minute (GPM) over the entire space (See Section 5.1.3).

Finding: Detector spacing in 2nd Floor "RF and Electric Shop" and the "Upper Equipment Bay" areas exceeds NFPA 72 spacing requirements. Current spacing is inadequate and will cause a fire to develop beyond an acceptable amount of time due to the delay in a detector sensing the fire.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-930-02: Additional detectors shall be installed to conform to NFPA 72 standards (See Section 5.3).

Finding: Data collected from the experiment is vital. This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network).

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-930-03: Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).

Finding: A lightning protection system is not provided for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-930-04: Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).

Finding: There is no record that the sprinkler systems and standpipe system has been hydrostatically tested and has been flushed.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-07-930-05: The automatic sprinkler systems and standpipe system should be hydrostatically tested and flushed in accordance with NFPA 25 criteria to ensure their operability, (See Section 5.1.3).

The following is a summary of recommendations and their relative priority.

Rec.No.	Recommendation	RAC
HAI-07-930-01	Automatic sprinkler protection should be provided in Pit #2.	3
HAI-07-930-02	Additional detectors shall be installed in the 2nd Floor "RF and Electric Shop" and the "Upper Equipment Bay"	3
HAI-07-930-03	Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).	3
HAI-07-930-04	Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).	3
HAI-07-930-05	Hydrostatically test and flush the sprinkler and standpipe systems	4

1.3.2 Outstanding Recommendations from Previous Reviews

ADS99-930-01 Significant amounts of exposed polystyrene insulation building materials are used in the construction and operations at the LINAC. The insulation is in both sprinklered and unsprinklered areas in the building. There is an outstanding ADS to replace the insulation in the building.

LSC90-930 – 2 The non-rated doors and assemblies at the main entrance to the accelerator room from the control room, should be upgraded to 1 hour rated doors and assemblies.

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted in November 2006, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The Building Code of New York State 2002 Edition (BCNYS)

International Code Council (ICC), International Building Code (IBC) 2003 Edition;

ICC, International Fire Code (IFC) 2003 Edition

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

3.0 LOCATION

Building 930 is located in the central west region of Brookhaven National Laboratory (BNL). BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York.

4.0 CONSTRUCTION

4.1 Occupancy Classification

Building 930 is classified by BCNYS (Sec. 306.1) as "Factory Industrial F-2 Low Hazard" occupancy." NFPA 101 (3.3.152.8.3) classifies this buildings as "Industrial, Special Purpose" occupancy.

4.2 Construction Type

The 200-MeV LINAC (LINAC) consists of Main Building (930) and two additions: Power Supply Area (930A) and the Experimental High Bay Area (930B).

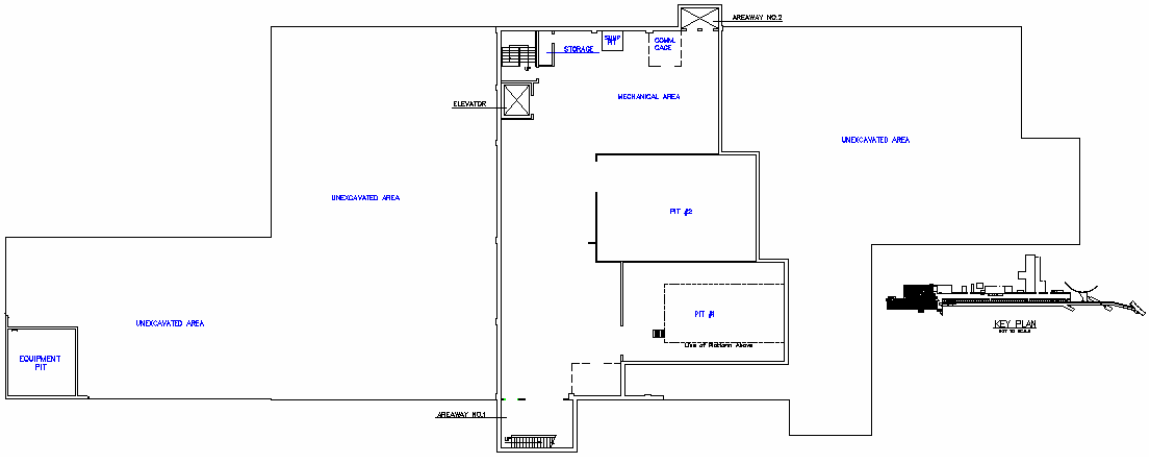
Building 930 is a two story steel frame building that was built back in the 1960's. It has floor dimensions of 100 ft. by 700 ft on the first and second floors (interior dimensions). The building has a partial basement with floor dimensions of 100 ft. by 75 ft. On the first floor is the 800 foot LINAC tunnel, lower equipment bay, terminal room, assembly and tech shops, ion source room, and laboratories. On the second floor there is the RF and Electrical shop, upper equipment bay, control room, offices and labs. In the basement are mechanical rooms and storage. A mezzanine level is located above the Terminal Room floor. The exterior walls are considered to be equivalent to non-combustible construction. The foundation is poured concrete. The floors are concrete slab. Opening in the floors exist between the first and second floor in the equipment bay area. The removable metal plate openings allow cabling between power supply cabinets on the 2nd floor to connect to the LINAC tunnel equipment on the 1st floor. Interior walls are concrete block or gypsum board on studs. In the few areas with ceilings (offices, control room)

non-combustible suspended ceilings is provided. The roof is a built up roof classified as Factory Mutual (FM) “Class 1” as well as Underwriter’s Laboratories (U/L) “Class A.” The roof was refurbished in 1997. Multiple HVAC zones exist in the building.

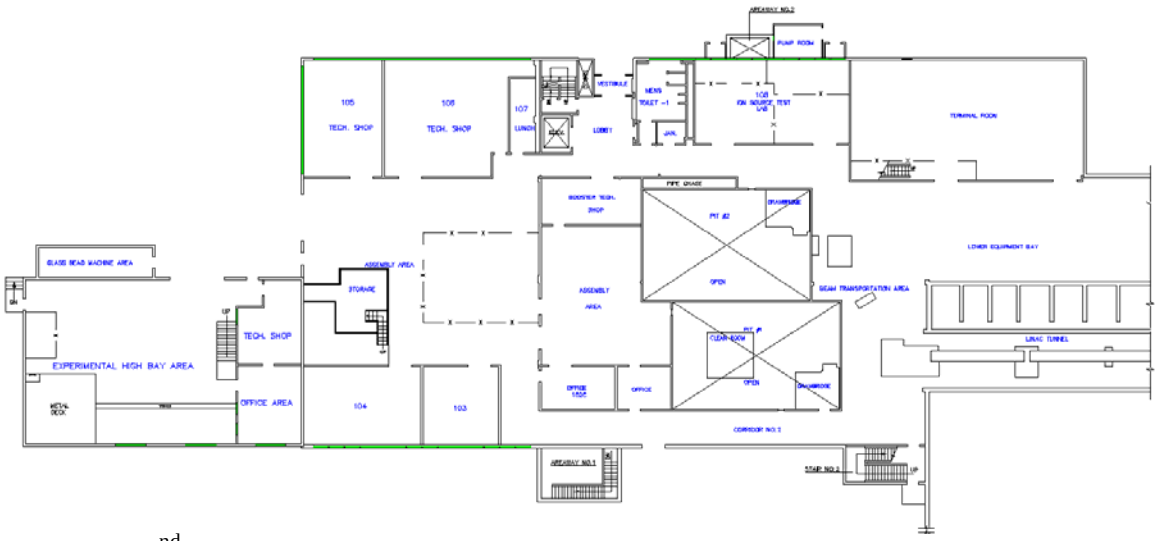
Building 930A is a single story structure attached to building 930 on the Southeast side. It was built back in the 1970’s and has a floor dimension of 40 ft. by 150 ft. The structure houses power supplies for the LINAC tunnel. The building was built on grade. The exterior walls are considered to be equivalent to non-combustible construction. The foundation is poured concrete. Interior walls are concrete block or gypsum board on studs. The roof is a built up roof classified as FM “Class 1” as well as U/L “Class A.” The roof has been refurbished. One HVAC zone exists for the building.

Building 930B attached to building 930 on the Northwest side. It is a single story structure with a partial enclosed mezzanine level and it was built back in the 1990’s. Building 930B has a floor dimension of 40 ft. by 70 ft. The building was built on grade. The exterior walls are considered to be equivalent to non-combustible construction. The foundation is poured concrete. Interior walls are concrete block or gypsum board on studs. In the few areas with ceilings non-combustible suspended ceilings is provided. The roof is a built up roof classified as FM “Class 1” as well as U/L “Class A.” The roof has not been refurbished since it was installed in the 1990’s. One HVAC zone exists for the building.

Northwest Basement (Buildings 930 & 930B)

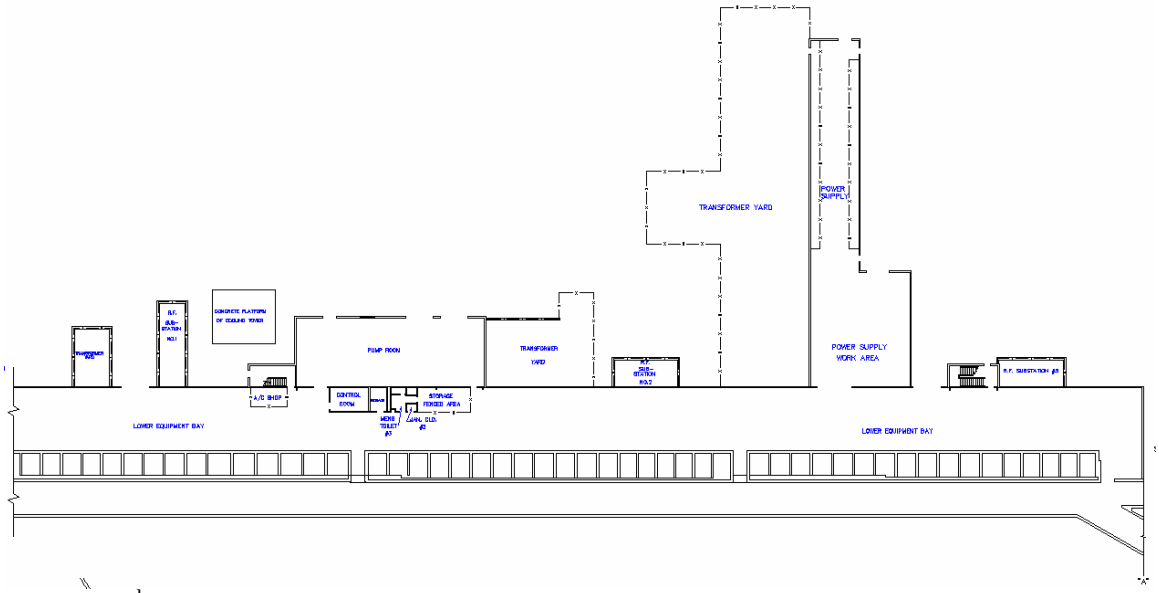


Northwest 1st Floor (Buildings 930 & 930B)



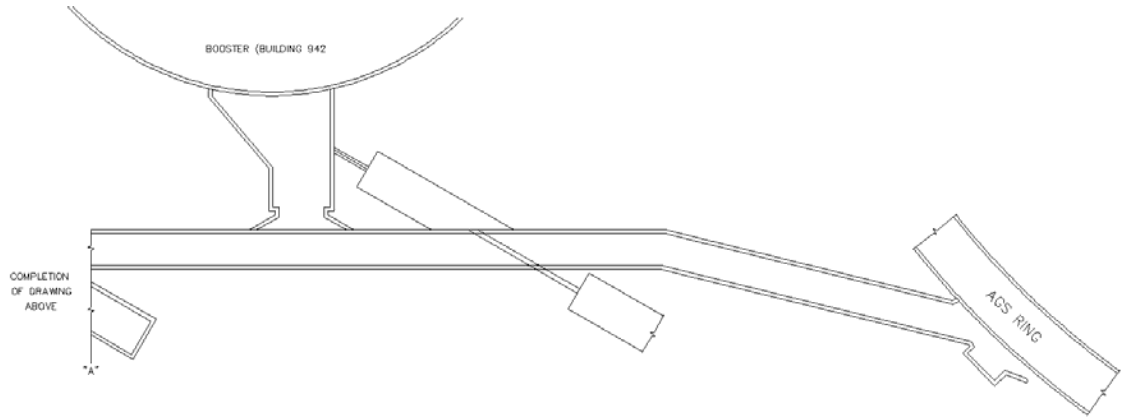
Northwest 2nd Floor (Buildings 930 & 930B)

Middle 1st Floor (Buildings 930 & 930A)



Middle 2nd Floor (Buildings 930 & 930A)

Southeast 1st Floor (Building 930 Tunnel)



Life Safety Code

The LSC does not specify a minimum construction type for existing special purpose industrial occupancies [§39.1.6; §40.1.6]. The LSC permits an occupant load of not more than 1,000 persons and located at the level of exit discharge to be within a building of Type II(000) construction regardless of automatic sprinkler protection [LSC Table 13.1.6]. Thus, the existing construction complies with LSC requirements.

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type. Building 930 is listed as 256,548 (gross) square feet in area.

International Building Code

In accordance with the IBC, Buildings and structures designed to house low-hazard industrial processes that require large areas and unusual heights to accommodate craneways or special machinery and equipment including, among others, rolling mills; structural metal fabrication shops and foundries; or the production and distribution of electric, gas or steam power, shall be exempt from the height and area limitations of Table 503 [IBC 503.1.2].

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building. Due to the nature of the RHIC, interior passive fire protection features are not provided.

4.3.1 Fire Areas

A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions.

Building 930 is not subdivided. The facility complies with the codes of record with respect to occupancy separations. There are no areas in this facility that are defined as incidental or accessory occupancy use areas as noted in BCNYS “§302.1.1” or NFPA 101 §6.1.14.1.2 and “§6.1.14.1.3.”

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing installed systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and one 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out of service and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the vicinity of Building 930 has a static supply pressure of 52 pounds per square inch (PSI) at low elevated tank levels; 65 psi normally. The water supply system in the area can supply about 5,500 GPM at 20 PSI (based on the Water Distribution Model Analysis developed by the Fire Protection Engineering Group during the summer of 2004.)

Frost proof Fire hydrants are provided within 300 ft of the entrances into the tunnel. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

The LINAC has a two 8 inch ductile iron mains connected to an 8 inch main along West Fifth Avenue. One service main is for the west side sprinkler system that enters the basement on the north wall of the building. The other main, supplies the east side sprinkler system that enters north wall of the pump room on the first floor. The basement and the pump room on the first floor have an exterior door which can be used for Fire Department access. Both mains have an 8 inch Post Indicating Valve (PIV) located more than 40 feet from the building. The PIV’s are gate valve type valves. The valves have electric tamper switches.

The mains are not combined with the domestic water system. Each main continues to a combined sprinkler/standpipe Alarm Check Valve Assembly. This configuration does not meet the current BCNYS requirement of a double check valve on the fire protection system to prevent contamination to the potable water supply.

Each main has a Fire Department Connection (FDC). The FDCs are located on the north side of the building 930 exterior wall. The nearest hydrant is less than 400 feet from the fire department connection as required by code. The two 2 ½ inch outlets on the FDCs conform to National Standard Thread couplings standards. The piping between the Fire Department Connections and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the discharge side of the Alarm Check Valves.

5.1.3 Sprinkler Systems

Automatic fire suppression system protection, conforming to NFPA 13, is provided in all areas except for the LINAC tunnel, the upper equipment bay, the elevator shaft, and Pit 2. There are two wet pipe sprinkler system zones.

The northwest side sprinkler zone consists of the entire basement and building 930B, on the first floor: the assembly & tech shops, lobby, offices, ion source test lab, the terminal room, and on the second floor: the A/C penthouse, offices, and control room.

The southeast side sprinkler zone consists of building 930A, the lower equipment bay on the first floor and stairs 3 & 4 on the second floor.

Pit # 2 does not have any sprinkler or detection protection. Currently the space is being used for storage. A recommendation is provided to provide sprinkler protection from the northwest side sprinkler zone system piping. (**Refer to recommendation HAI-07-930-01**)

The standpipe and sprinkler piping shall be hydraulically pressurized per National Fire Protection Association (NFPA) codes to verify the integrity of the systems. (**Refer to recommendation HAI-07-930-05**)

The standpipe and sprinkler piping shall be flushed per National Fire Protection Association (NFPA) requirements. (**Refer to recommendation HAI-07-930-05**).

Each sprinkler system has an Alarm Check Valve assembly. The Alarm Check Valve assemblies are 8 inch and are manufactured by Central Sprinkler Corporation (CSC). It is U/L and FM listed and provides the required alarm signals for flow activation to the building fire alarm panel.

The wet pipe sprinkler systems are hydraulically sized to meet 0.15 GPM per square foot over the most remote 2500 square feet.

5.1.4 Fire Standpipe Systems

There are two wet standpipe systems conforming to NFPA 14 is installed in this facility. The class of the standpipe systems, as listed in the BCNYS, is “Class II” systems. Each standpipe system is connected to automatic sprinkler system piping. Stair 1 hose valves are connected to the Northwest side sprinkler zone system piping, fire department connection and service main. Hose Valves in Stairs 2 & 3 are connected to the Southeast side sprinkler zone system piping, fire department connection and service main.

5.1.5 Other Suppression Systems

The facility has a fire alarm system that is connected to the Site fire Alarm system. The two systems are as follows.

5.2 Fire Alarm Systems

The facility is provided with a fire alarm system.

5.2.1 Building Fire Alarm System

The LINAC has a building fire alarm system consisting of a fire alarm panel, manual stations, and visual and audio alarm notification devices conforming to NFPA 72. The fire alarm panel is located in lobby on the first floor. The fire alarm panel is a Simplex/Grinnell 4100U (panel 150A). The panel is connected to the Site Fire Alarm System via the copper wire in the site underground telecommunication infrastructure network.

5.2.2 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class “A” System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by using the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication “loops.” It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

Automatic detection systems are used in certain areas of the facility. The table below lists the detector types and indicates if their spacing conforms to the requirements of NFPA 72, National Fire Alarm Code.

Detector spacing in 2nd Floor "RF and Electric Shop" and the "Upper Equipment Bay" areas exceeds NFPA 72 spacing requirements. Current spacing is inadequate and will cause a fire to develop beyond an acceptable amount of time due to the delay in a detector sensing the fire. Additional detectors shall be installed to conform to NFPA 72 standards. (**Refer to recommendation HAI-07-930-02**)

Location	Detector Type(s)	Connected To	Coverage Type	Spacing Complies with NFPA 72
Pit #1	P	FACP	Room	Yes
LINAC Tunnel	F/R	FACP	Room	Yes
Building 930A	P, I	FACP	Room	Yes
2nd floor Control Room	HSSD	HSS/DCP	Room	Yes
2nd floor RF and Electronic Shop	F/R	FACP	Room	No
2nd floor Labs 1,2,3	F/R	FACP	Room	Yes
2nd floor Upper Equipment Bay	F/R, I	FACP	Room	No

Symbols

F:	Fixed Temperature Heat Detectors
FACP:	Fire Alarm Control Panel
F/R	Fixed/Rate of Rise Heat Detector
HCP:	Halon Control Panel
HSSD:	High Sensitivity Smoke Detection System
HSSDCP:	High Sensitivity Smoke Detection Control Panel
I:	Ionization Smoke Detectors
P:	Photoelectric Smoke Detectors
R:	Rate of Rise Heat Detectors

5.4 Fire Extinguishers

Fire extinguishers are provided in the building. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Special Occupancies, Unique Fire Hazards, Housekeeping in Vital Areas, Building Materials, Exterior Exposure Hazards,

Natural Phenomenon Hazard Exposure, Toxic Fire Potential, Biological Fire Potential, and Radiation Fire Potential. The following is an evaluation of Building 930 for each category.

6.1 Special Occupancies

Special occupancies include: instrumentation and data processing equipment, vital and important records, trailers, cooling towers, electrical substations, flammable liquid and gas storage, cables and raceways, . The special occupancies applicable to Building 930 are expanded upon in Sections 6.1.1 thru 6.1.7, below.

6.1.1 Instrumentation and Data Processing Equipment

DOE/EP-0108 established levels of protection for Instrumentation and Data Processing equipment and the facility in which it is housed.

Automatic Smoke Detection Protection

The areas noted in table 6.3 above are provided with automatic detection coverage since the equipment in the areas exceed the $250,000 limit DOE establishes to require smoke detection protection.

Automatic Sprinkler Protection

Automatic sprinkler system protection, conforming to NFPA 13, is provided in all areas except for the LINAC tunnel, the upper equipment bay, the elevator shaft, and Pit 2. These areas do not exceed the 1 million dollar value limit to require sprinkler protection.

Fire Barriers

DOE requires fire barriers if the value of the structure and contents exceeds $50 million. No fire barriers are required by this DOE standard in this facility.

6.1.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or significant extra expense.

Based on the above definitions, the data collected from the experiments are considered vital records. Review of the backup procedure of data collected as part of this program is out of scope of this Fire Hazard Analysis but will be a recommendation to ensure it is being adequately protected in accordance with DOE requirements (**Refer to recommendation HAI-07-930-03**).

6.1.3 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 930.

6.1.4 Cooling Towers

The new prefabricated unit is of metal frame and walls with plastic fill will be installed to replace the current wood cooling tower during the spring of 2005. A fire in the new cooling tower will not cause damage to the Building 930 due to spatial separation and the limited amount of combustibles in the tower.

6.1.5 Electrical Substations

The transformers and switch gear are arranged to meet the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The transformers do not present an exposure hazard to the facility or each other since they have 1 hour fire barriers protection installed between building structures and between adjacent transformers.

6.1.6 Flammable Liquid & Gas Storage

The use of flammable liquids in the Building 930 is minimal. The quantity of flammable gases and liquids in the facilities are less than the limits mandated by BCNYS Table 307.7(1) "*Maximum Allowable Quantity per Control Area of Hazardous Materials Posing a Physical Hazard*." Use of flammable liquids is in accordance with BNL ES&H Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d481.pdf). The BNL Chemical Management System is designed to ensure that workers are informed about the chemical hazards in their workplace.

6.1.7 Cables and Raceways

High voltage, low voltage, control, and signaling cables are segregated in accordance with NEC requirements throughout the LINAC. The cabling is located in conduits, raceways and cable trays. In most instances, the cables provided in the cable trays do not meet the flammability test criteria in IEEE 383, VW-1, and/or National Electrical code (NEC) 0 rated wire for cable trays.

Each cable tray is provided with a single plastic bag filled with vermiculite to act as fire stops. The bags are located at 30 ft. intervals along the entire length of the trays. The quantity of cables does not represent a significant combustible load.

All cable trays are easily accessible to manual fire fighting. Cable tray fires are not fast spreading. With the existing early warning fire detection, a fire can be easily extinguished in its infancy. This philosophy of easy access by manual fire fighting efforts and early warning detection is described as acceptable in Factory Mutual Loss Prevention Data Sheet 5-31 "Cables and Buss Bars". Recover time to repair damaged cables is expected to be less then 3 months.

6.2 Unique Fire Hazards

There are no unique fire hazards in the building.

6.3 Housekeeping in Vital Areas

Good housekeeping and control of combustibles was observed during this survey. The Collider-Accelerator department self-inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

Significant amounts of exposed polystyrene insulation building materials are used in the construction and operations at the LINAC. The insulation is in both sprinklered and unsprinklered areas in the building. There is an outstanding ADS to replace the insulation in the building. (**Refer to Section 1.3.2)**

6.5 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

Elements Outside of the Facility

The following is a summary of fire exposures to the LINAC facility. All exposures are evaluated using FM Data Sheet 1-20 “Protection against Exterior Fire Exposure.”

North Exposures

Exposures to the North are minimal. The NASA Space Radiation Laboratory (NSRL) complex that is protected with automatic sprinklers is over 100 feet away.

South Exposures

Exposures to the South are minimal. The nearest structure is over 200 feet away.

East Exposures

Exposures to the East are minimal. The nearest structure is over 200 feet away.

West Exposures

The tree line is more than 20 feet away. Refer to Section 6.6.3 below for brush fire exposure.

Components of the Facility

Exposures between components of the facility are minimal. Sprinkler protection and passive fire barriers are in place to provide separation between components of the facility.

6.6 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.6.1 Lightning Potential

The lightning damage potential for the LINAC is a concern Based on NFPA standard 780 Appendix H "Lightning Risk Assessment "calculation. Following the Risk Assessment methodology the expected lightning frequency (Nd) is greater than the tolerable lightning frequency (Nc). The expected lightning frequency (Nd) is 0.0121 and the tolerable lightning frequency (Nc) is 0.0002 (calculations shown in appendix A of this document). NFPA 780 recommends when (Nd) is greater than (Nc) that a lightning protection system should be installed. (FHA04-930-06).

6.6.2 Windstorm Potential

The long Island area basic wind speed (3-second gust) is 120 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS figure 1609.4. The ground roughness exposure category for the LINAC area is 'Exposure B." Based on the calculations this buildings should have roof assemblies classified as "Class 90" rated assemblies. The condition of the roofs appears to be in good condition.

6.6.3 Brush Fire Potential

Based on the criteria presented for evaluating fire potentials from Wildland in the "*BNL Wildland Fire Interface Survey Report*," dated August 2002, there is no brush fire risk potential exposure to Building 930.

Additionally, an analysis was completed consistent with the requirements and guidelines of NFPA 1144 *Protection of Life and Property from Wildfire* (2002) to determine the wildfire risk to Building 930. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire protection, and utilities.

Based on the analysis, the hazard from wildfire to Building 930 is "LOW" (score of 30, with 40 being the cut-off for low hazard). Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.6.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation*" dated

April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.6.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled "*DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation.*"

Groundwater runoff from a severe rainstorm is not a concern for Building 930 due to the surrounding terrain.

6.7 Toxic Fire Potential

There are no known materials in the LINAC that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

6.8 Biological Fire Potential

There are no known biological materials present in the building that present a release potential due to fire.

6.9 Radiation Fire Potential

By the nature of the operations of the accelerator, various pieces of equipment can become activated. Since this is an ion accelerator, any levels are low. Small quantities of radioactive materials are used and stored in the LINAC. Activation and quantities stored and used in the LINAC is not expected to pose a significant environmental impact in the event of a fire since the material will not be easily disbursed..

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility (http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp). The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

There is no essential safety class systems associated with this non-nuclear facility.

7.2 Protection of Vital Programs

The operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are described in this report, are required for this facility.

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

Based on this definition there is no high value equipment located within Building 930. The power supplies, RF amplifiers, magnet power supplies have value and somewhat unique, but do not approach the definition of high value.

The highest value class of equipment appears to be the magnets which have an approximate value in the $100K to $200K range.

7.4 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a fire, could delay a significant component of a major program for a period in excess of 6 months.

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a critical fire, could delay a significant component of a major program for a period in excess of 6 months.

By the above definition, there are no areas in the LINAC that are considered critical process equipment.

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

The LINAC is considered one fire area and thus a single MPFL calculation is being performed.

Combustible loading throughout the building is relatively low and, with the exception of cables in cable trays there is a general lack of continuity of combustibles. Due to the overall volume of the facility, flashover is unlikely. Flashover indicates that the temperature inside an area would be sufficiently hot to cause multiple fuel package ignitions within the space and result in loss of all contents. Associated compartment temperatures at flashover are generally accepted to be between 500°C (900°F) to 600°C (1100°F). Flashover is generally defined as the transition from a growing fire to a fully developed fire. Fully developed fires impose extensive thermal and physical stresses on fire barriers, the failure of which could lead to fire spread throughout the area.

7.5.2 MPFL Calculation

The LINAC has a replacement value of approximately $15 million ($12,333,010). The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement value divided by the floor area of the building $\$15{,}000{,}000/103{,}647 ft^2 = \$145/ft^2$.

The content and equipment value is calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building.
- There were no available replacement costs provided for the equipment within Building 930. For the purposes of this FHA the value is assumed to be approximately $10,000,000, based on the uniqueness of the various magnets and power supplies.

MPFL Summary

Attribute	Value
Building Value	$15,000,000
Contents	$10,000,000
MPFL Total	$25,000,000

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

The maximum credible fire scenario is one in which automatic suppression systems function as designed. For the purposes of the MCFL determination a design area of 3,000 ft^2, is assumed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area this floor area was used in the determination of MCFL potentials when protected by automatic sprinkler systems. For those buildings without sprinkler protection the MCFL is the same as the postulated MPFL for that area. The following building cost factors are approximated and have been utilized in the determination of the MCFL:

Building	Cost ($)	Area (ft^2)	Factor ($/$ft^2$)
930	$15,000,000	103,647	145

MCFL Summary

Building 930 ($103,647 ft^2$)		$ Value
Building	3000 ft^2 x $145/$ft^2$ =	$435,000
Contents	3000 ft^2 x $100/$ft^2$ =	$300,000
	MCFL	$735,000

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Building 930	$25,000,000	$735,000

7.6 Recovery Potential

Critical process parts have been identified by the Department. Critical process parts are those items essential to the operations and that require a long lead-time for replacement. It is unlikely that fire damage will result in a disruption of operations exceeding 6 months. Within the facilities of the LINAC, critical process parts have been identified by the Department. Critical process parts are those items essential to the operations of the accelerator that require a long lead-time for replacement. These spares are stored in a separate building, not subject to a common incident.

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. A minimum of two members per shift hold New York State "Emergency Medical Technician - D" certifications ("D" is for defibrillation). Normally all five

firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 930 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency. Roadways are located on the north, east and south sides of the building.

7.9 Security Considerations Related to Fire Protection

The facility will have security measures to restrict access, including the use of card readers. Provisions will be made for Fire/Rescue access via card reader programming, provision of master key, or installation of interlocked crash doors. Ingress includes interlocked crash panels in the doors to allow emergency entry.

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101®, the Life Safety Code (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures. This building was likely constructed to comply with the latest version of the Life Safety Code NFPA 101 at the time of construction. DOE now requires all buildings to conform to local building codes and NFPA 101.

8.1 Occupancy Load Factor and Calculations

Occupancy load factor and calculations

The occupant load per floor level for code purposes is calculated in Table 8.1-1 based on applicable occupant load factors specified in LSC Table 7.3.1.2. An occupant load factor of 300

sq ft per person was applied to special-purpose industrial and mechanical/electrical equipment areas. Factors for these spaces are not specified in the LSC.

Location	Occupancy Load Factor (per person)		Area (feet)	Occupancy Load Calculations					
				Basement		1st Floor		2nd Floor	
	BCNYS	NFPA		BCNYS	NFPA	BCNYS	NFPA	BCNYS	NFPA
Basement: Mechanical Equipment Area	300 gross	0	3,800	13	0				
Basement; Pits 1&2	100 gross	100 gross	2,400	24	24				
1st Floor: Lower Equipment Bay, Pump Rm.,	100 gross	0	18,000			180	0		
1st Floor: General Offices, Machine Shops	100 gross	100 gross	15,000*			150	150		
1st Floor: LINAC Tunnel	100 gross	0	13,000			130	0		
2nd Floor: Mechanical Rm.	300 gross	0	1,200					4	0
2nd floor: Upper Equipment Bay	100 gross	0	19,500					195	0
2nd Floor: Labs 1-3, Office Area, Control Rm.	100 gross	100 gross	5,558					56	56
TOTAL			78,458	37	24	460	150	255	56
Building 930A	100 gross	0	4,000			40	0		
Building 930B	100 gross	100 gross	3,700*			37	37		

* Includes Mezzanine Areas

8.2 Means of Egress

The means of egress for the building meets the present code requirements for number and arrangement of exits, capacity of exits, travel distance, common path of travel, dead ends, and security considerations related to egress. The following subsections provide the egress detail for each of the elements.

8.2.1 Number and Arrangement of Exits

The LSC requires that a floor with an occupant load of 500 or fewer persons must have a minimum of two means of egress [§7.4.1.1]. Additional exits may be required for compliance with exit capacity or arrangement of exits criteria.

The Basement of Building 930 has two stairs. The exterior 36 inch clear width stair on the south side leads to grade is label "Areaway No. 1." The second stair, located on the north side is labeled "Stair No. 1." It is 36 inch clear width stair in a fire rated enclosure that discharges to the lobby on the 1st floor.

On the 1st floor of Building 930 there are eight exits. Four of the exits lead directly to the exterior of the building. Three enter enclosed stairs that have exits to the exterior of the building one exit leads from the LINAC tunnel into the AGS tunnel. All the exits have doors with a minimum of 36 inch clear width.

The 2nd floor of building 930 has five exits. One of the exits leads directly to the exterior of the building. Four enter enclosed stairs that have exits to the exterior of the building on the 1st floor. All the exits have doors with a minimum of 36 inch clear width.

Building 930A has two exits. Both exits lead to the exterior of the building. All the exits have doors with a minimum of 36 inch clear width.

Building 930B has two exits. Both exits lead to the exterior of the building. All the exits have doors with a minimum of 36 inch clear width.

8.2.2 Capacity of Exits

The available exit capacity of Building 930 exceeds the low occupant loading based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components.

8.2.3 Travel Distance

Building 930 egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 400 feet in this type of sprinklered F-2 occupancy. NFPA 101 (Table 40.2.6 and Section 40.2.6.3) limits egress travel distance to 400 feet in this type of sprinklered Industrial Special Purpose occupancy.

8.2.4 Common Path of Travel

The LINAC exceeds the common path of travel distance limits of BCNYS and NFPA 101 in one area. The common path of travel distance in the extreme southeast corner on the 2nd floor in the Upper Equipment Bay of building 930 is over 70 feet. NFPA 101 "Table 40.2.5" limits common path of travel distance to 50 feet in this type of non-sprinklered occupancy. BCNYS (1004.2.5) limits common path of travel distance to 75 feet in this type of non-sprinklered occupancy. While the length does exceed the common path limits, a combination of open sight

lines, the infrequent occupancy and the installed smoke detection system provides an adequate level of early warning protection for the area.

8.2.5 Dead Ends

Per Section 40.2.5.2 of the Life Safety Code, and the Fire Code of New York State (FCNYS) (Table 1010.17.2) a dead end corridor cannot exceed 50 feet. The building is in compliance with this criterion.

8.2.6 Security Considerations Related to Fire Protection

The facility has security measures to restrict access, including the use of card readers. Provisions will be made for Fire/Rescue access via card reader programming, provision of master key, or installation of interlocked crash doors. Ingress includes interlocked crash panels in the doors to allow emergency entry.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §]. The building is provided with a two primary exits that are compliant, that meet this requirement.

8.3 Exit Signs and Emergency Lighting

Placement of exit signs in the building meets NFPA 101 and BCNYS “1003.2.10.”

Emergency lighting of all means of egress is provided in the building is provided by U/L listed battery powered light fixtures mounted on the walls. Emergency lighting of all means of egress is required by BCNYS “1003.2.11” and NFPA 101 “40.2.8.”

8.4 Emergency Roof Exits

A means of escape is defined as a way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out [LSC §3.3.152]. The building has no such arrangement.

8.5 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. The building complies with this requirement.

8.6 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. The LSC permits a maximum of 50 percent of the required number of exits to discharge inside the building provided the level of discharge is fully-sprinklered or the area of discharge is sprinklered and separated from the remainder of the building by fire barriers [§7.7.2.2; §7.7.2.4]. The criterion does not apply to Building 930.

8.7 Horizontal Sliding Doors

There are no horizontal exit doors utilized in Building 930.

8.8 Fire Escape Ladders

Fire escape ladders complying with 7.2.9 are permitted in industrial and business occupancies [§40.2.2.10; §39.2.2.10]. Fire escape ladders are permitted as means of egress only where one of the following conditions exists:

- Access to unoccupied roof spaces as permitted by 7.2.8.3.4.
- Secondary means of egress from boiler rooms or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.
- Means of egress from towers and elevated platforms around machinery or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.

There are no fire escape ladders provided in the building.

8.9 Door Heights

Means of egress are required to provide a headroom clearance of not less than 6 ft 8 in. at doorways [LSC §7.1.5.1]. The existing doors meet this requirement.

8.10 Discharge to Roofs

Exits are permitted to discharge to roofs or other sections of the building where the following criteria are met and with approval by the authority having jurisdiction [LSC §7.7.6]:

- The roof/ceiling assembly construction has a fire-resistance rating not less than that required for the exit enclosure.
- A continuous and safe means of egress from the roof is available.

There are no exits that discharge to the roof of the building.

8.11 Barriers

8.11.1 Occupancy Separations

Occupancy separations are not required for Building 930 since there is a single occupancy for the building.

8.11.2 Incidental Use Areas

Incidental use areas or hazardous areas are considered those spaces that pose a relatively higher hazard than the predominant occupancy of the area in which they are located. Such spaces are not necessarily classified as high-hazard (Group H) occupancies. Hazardous areas include general storage rooms, boiler or furnace rooms, and maintenance shops. The LSC requires hazardous areas to be separated from adjoining areas by a 1-hour fire resistance-rated barrier without windows or protected by automatic fire suppression systems [LSC §8.7.1.1]. Rooms with severe hazards such as maintenance shops with woodworking and painting are required to have both fire barrier enclosure and automatic fire suppression.

There are no such rooms associated with Building 930.

8.11.3 Separation of Means of Egress

Not applicable to Building 930.

8.11.4 Exit Access Corridors

There are no exit access corridors in Building 930, thus this criterion does not apply.

8.11.5 Vertical Opening Barriers

Building 930 is designed in certain areas to be a single zone. The second floor slab between the Lower and Upper Equipment Bay has multiple floor openings created by a metal plate panel system to facilitate passing cabling and mechanical services to the LINAC tunnel on the 1st floor. This makes both floors. There is a limited amount of fire rated door on the second floor to separate the equipment rooms from the office and control room areas. a single zone since there is limited rated walls on the second floor to separate the areas with the floor openings

One-half hour rated vertical barrier is provided for the cable tray trenches between the Accelerators/ Target rooms and the basement mechanical equipment room. New cabling has been added to some of the openings and the rated enclosure has not been reinstalled. (See FHA04-901A-1)

8.11.6 Egress Stairways

Egress stairways are provided around the Collider Ring. See Section 8.2.1.

8.12 Fire Protection Systems Required by Code

Automatic sprinkler protection is not required to address life safety conditions found in the building.

8.13 Operational Requirements that are Required by Code

When performed, cutting and welding operations in the building are required to be conducted in accordance with NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition.

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 220, Standard on *Types of Building Construction*

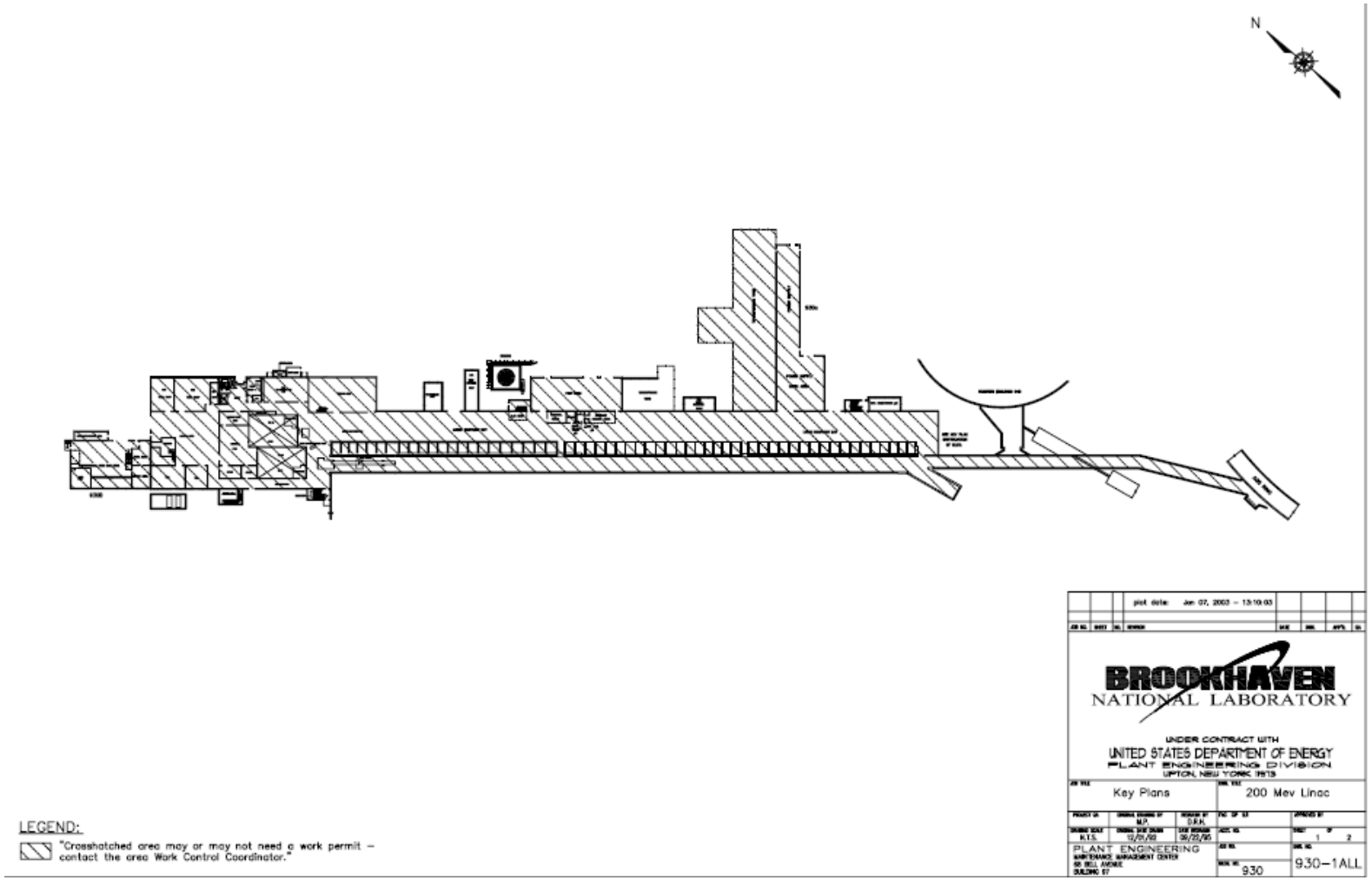
NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

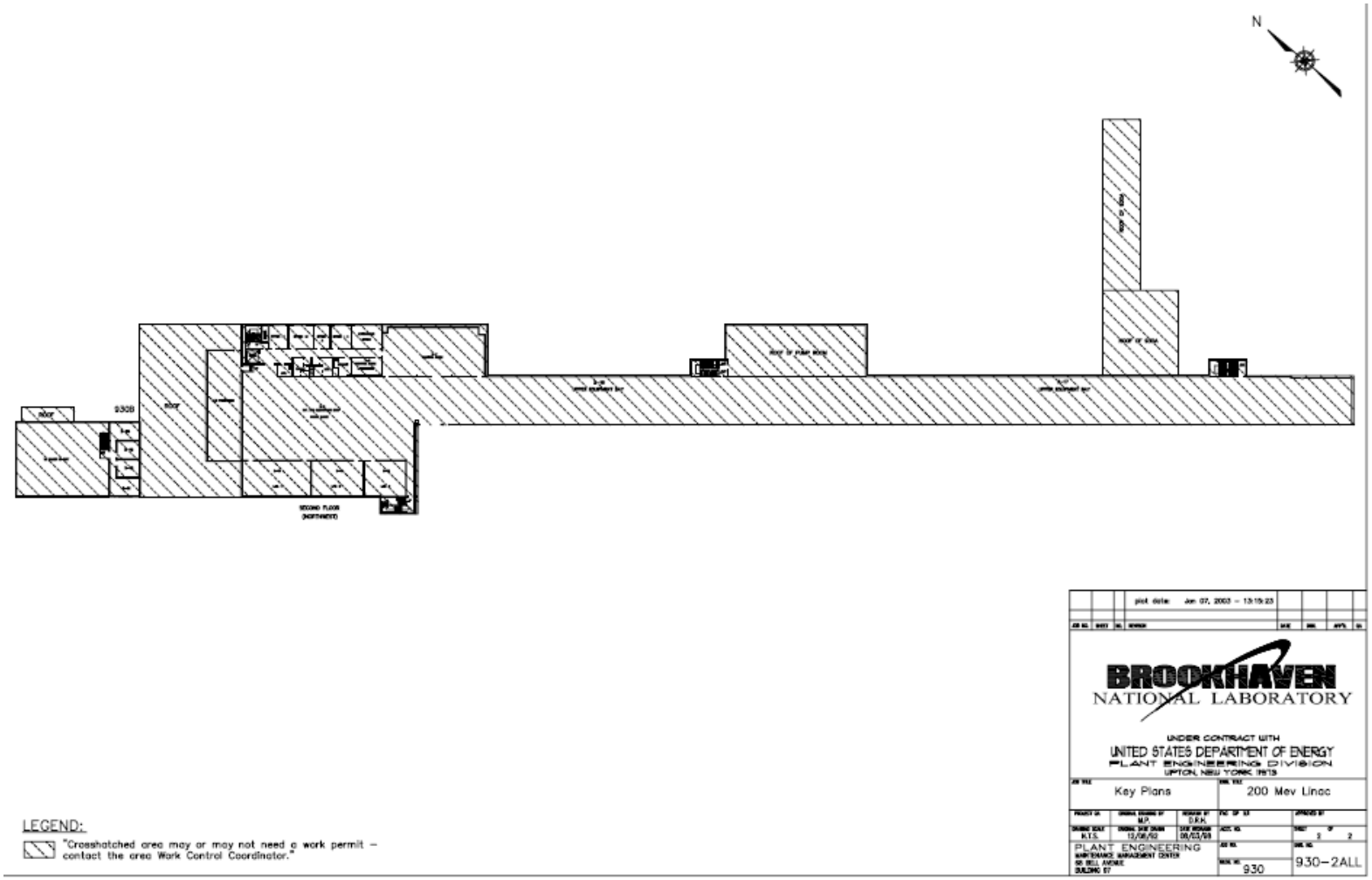
9.2 FM Global Loss Prevention Data Sheets

None.

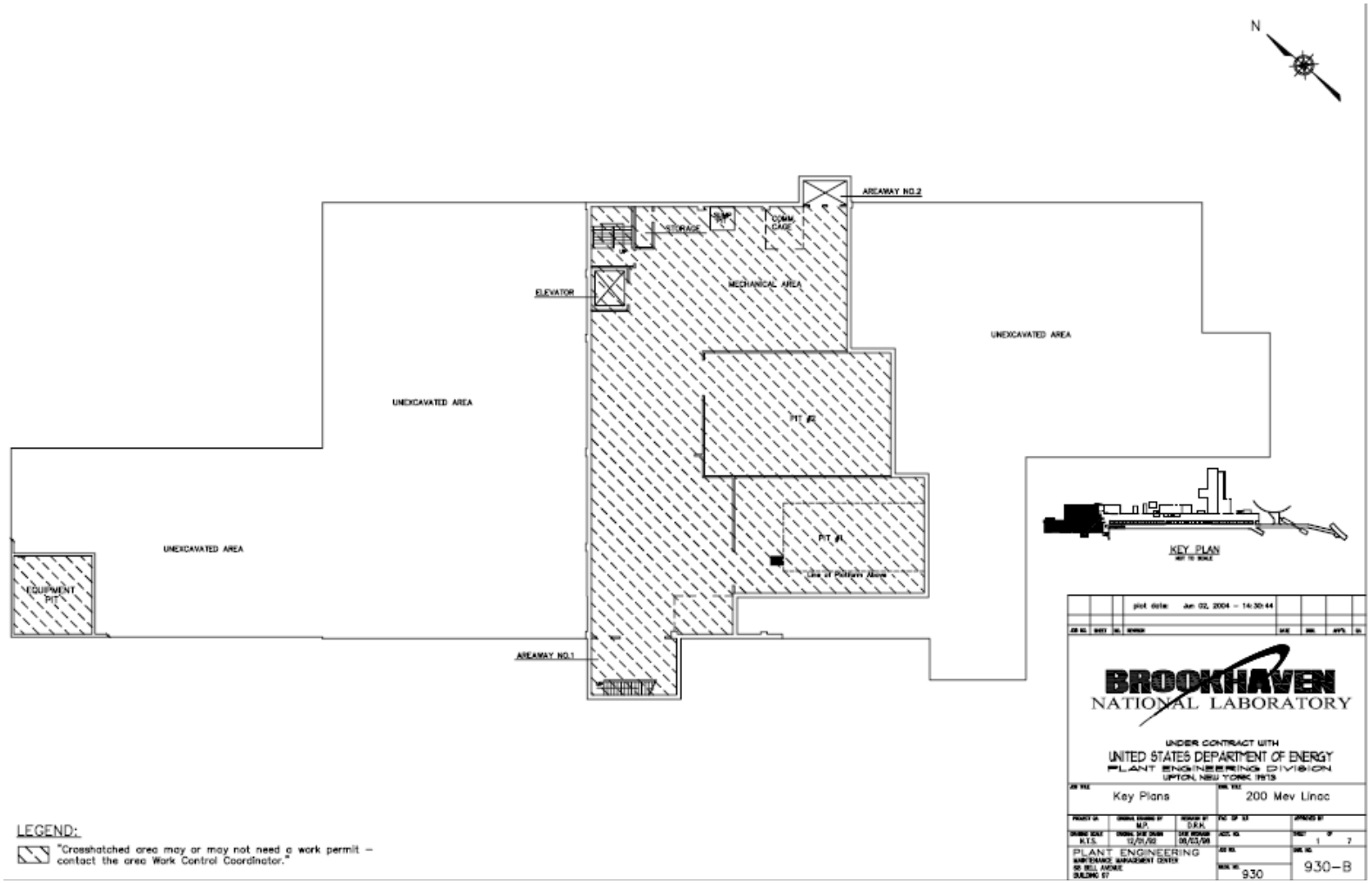
APPENDIX A – FHA FIGURES



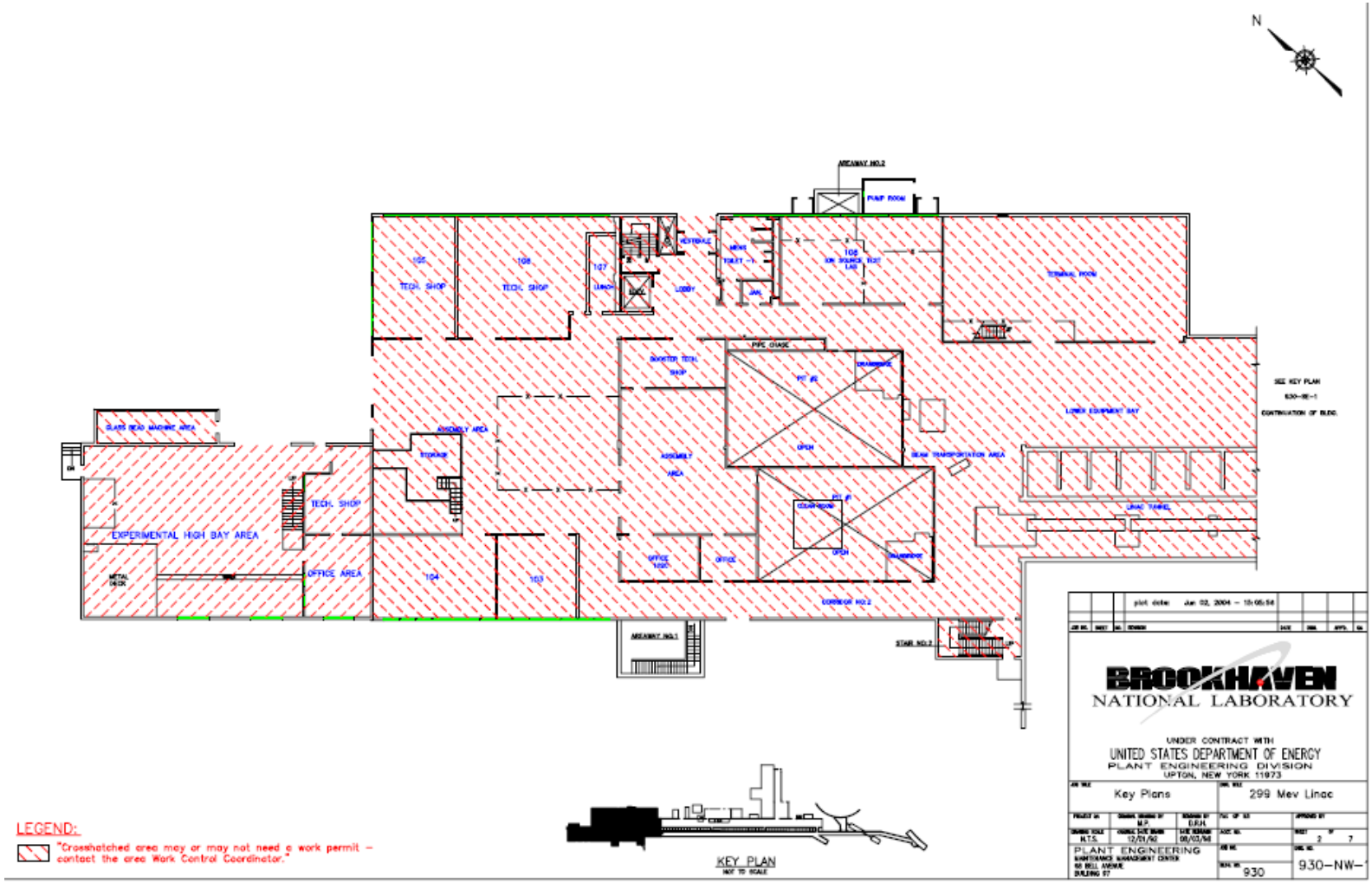
Building 930 – First Floor



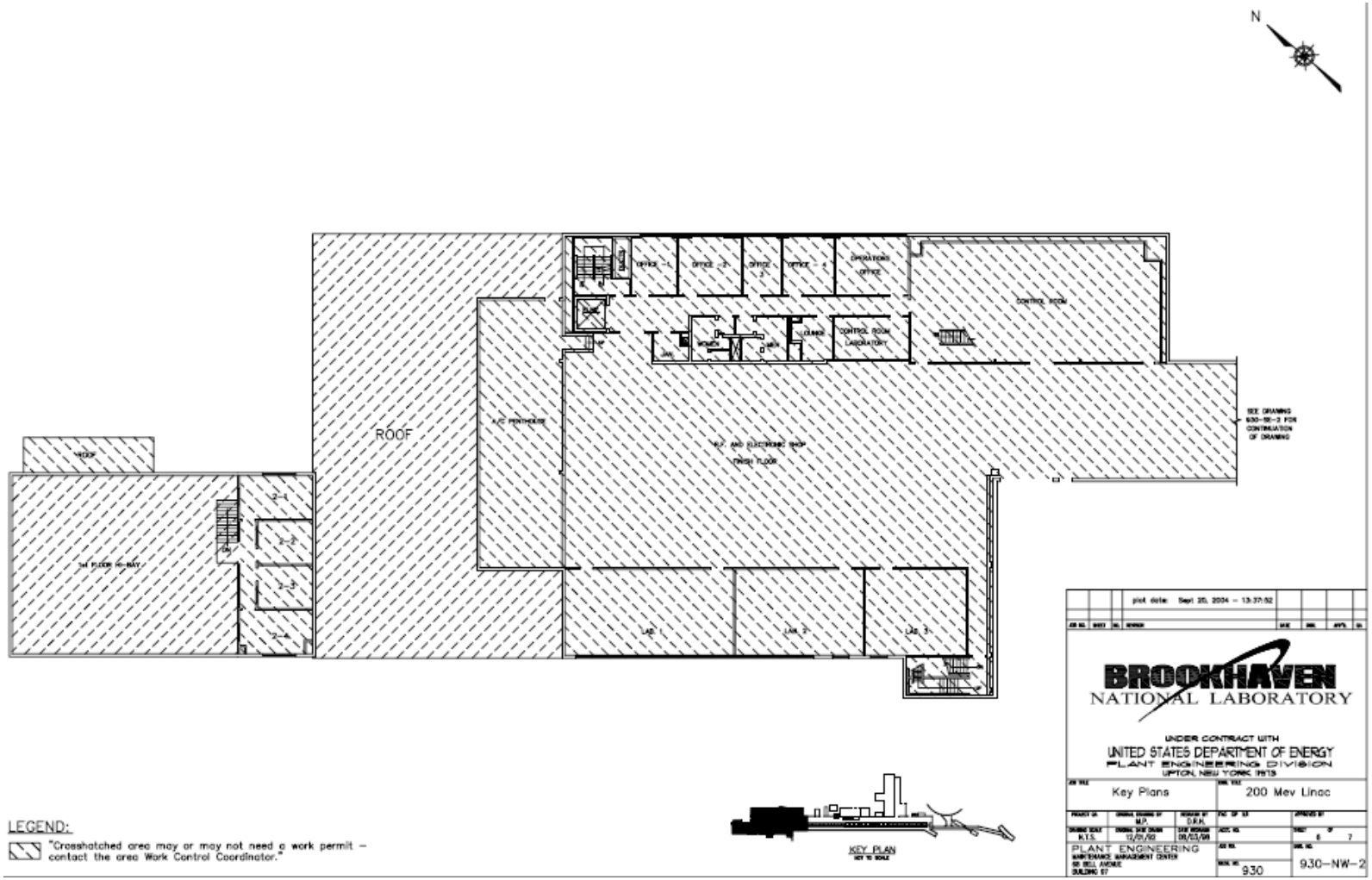
Building 930 – 2nd Floor



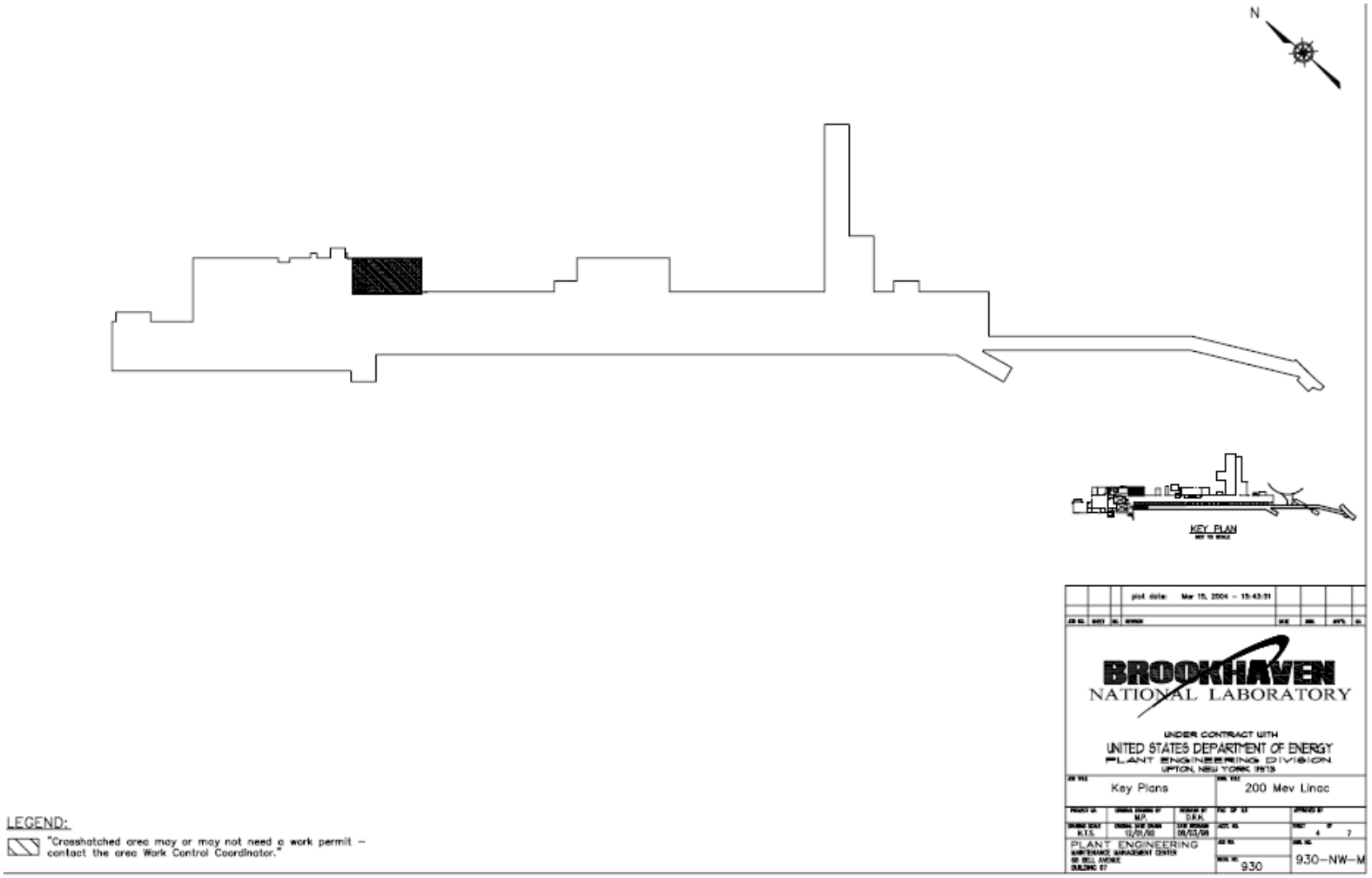
Building 930 - Basement



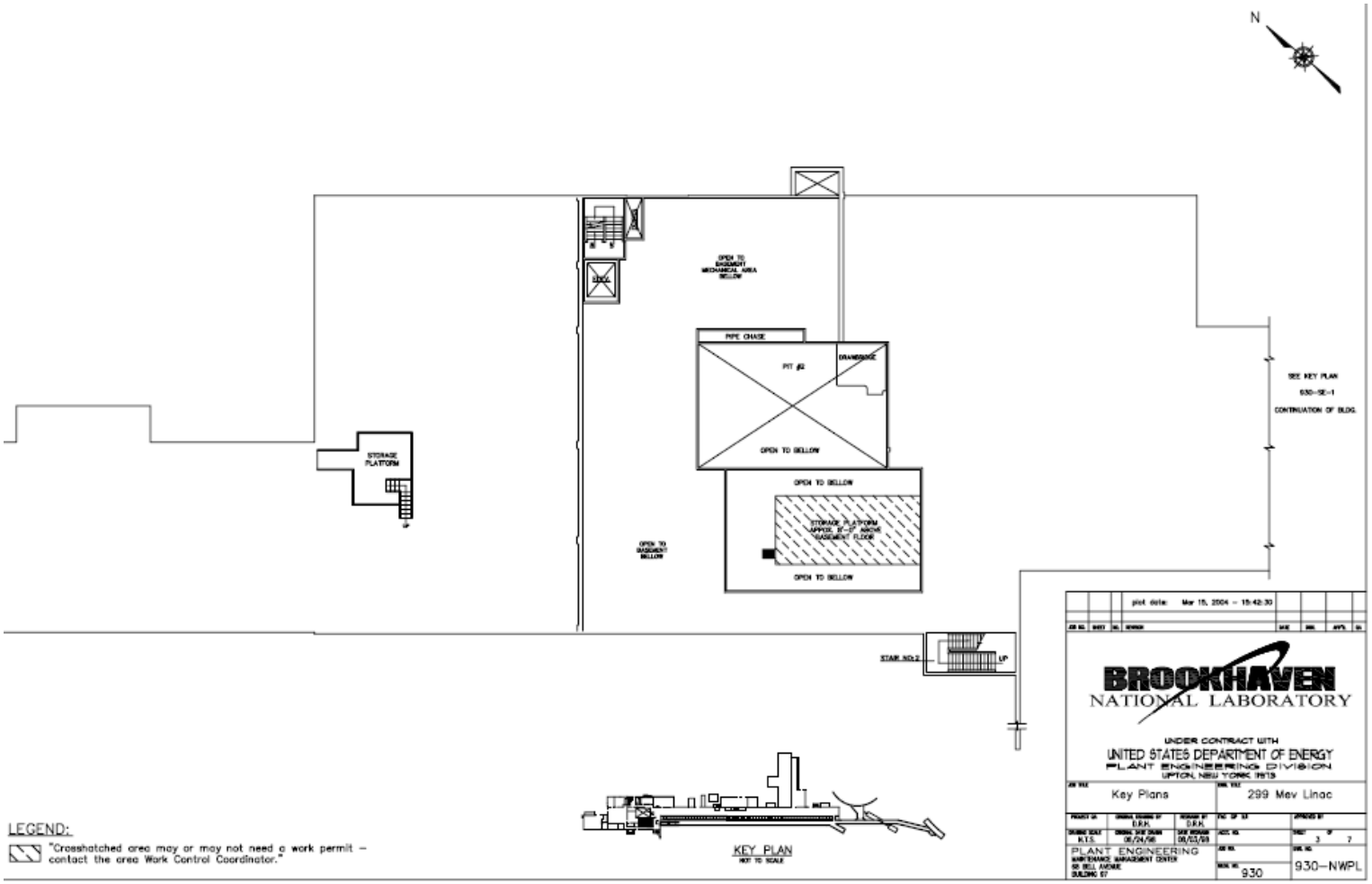
Building 930 – NW Section



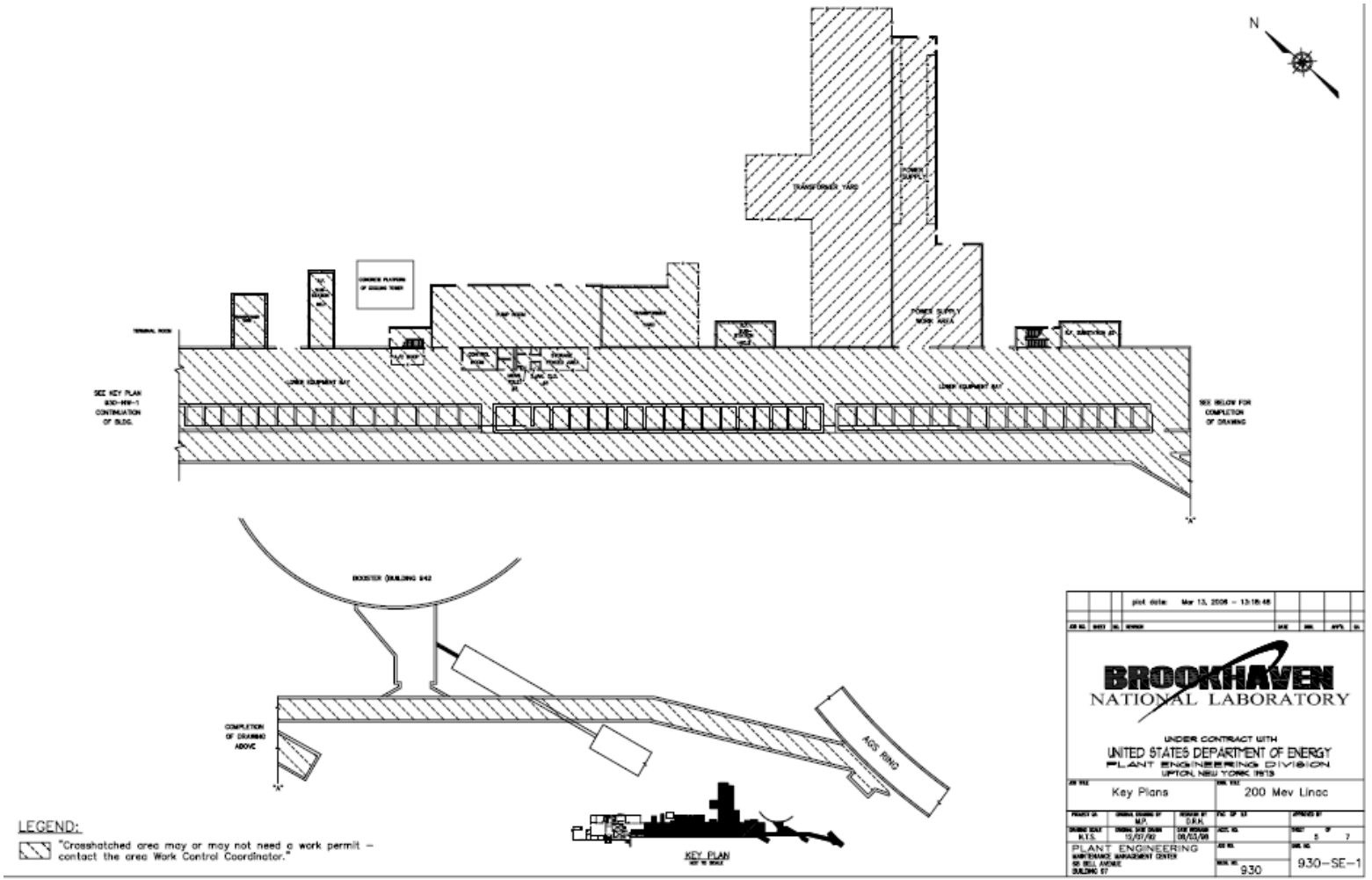
Building 930 – Northwest Section, 2nd floor



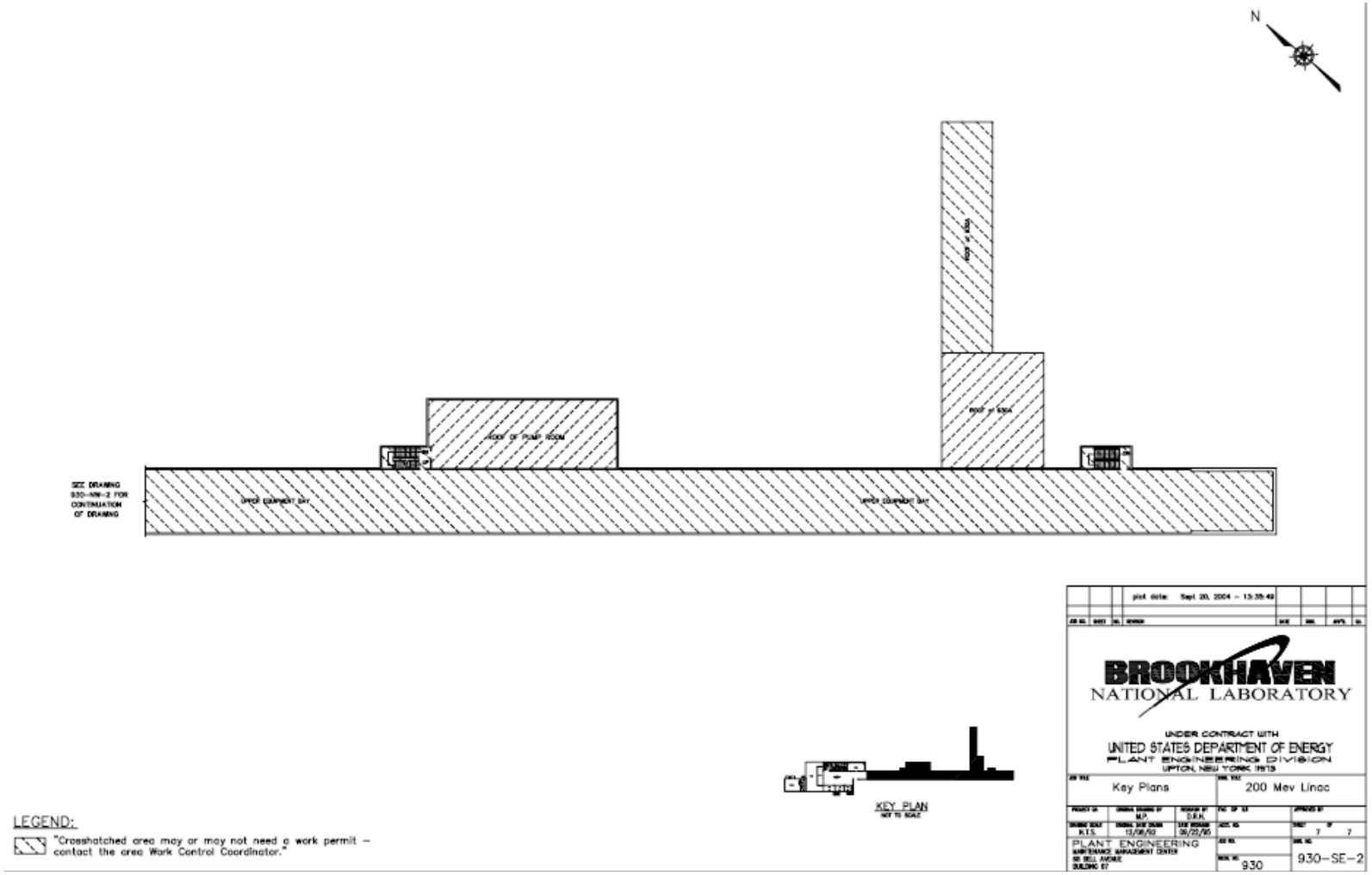
Building 930- NW Section, Mezzanine



Building 930 – NW Section - PL



Building 930 – SE Section



Building 930- SE Section, 2nd floor

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0** and the tolerable lightning frequency (Nc) is **0.0002**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d = **0.0121** = yearly average flash density in the region where the structure is located

(N_g) = **2.0** = the yearly lightning strike frequency to the structure

(C_1) = **0.25** = the environmental coefficient

(A_e) = **24,188** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	**650**	Feet
Width (W)	**30**	Feet
Height (H)	**45**	Feet

0.25

Figure H.4.2(a) Results 24,188 sq. meters

Figure H.4.2(b) Results 5,319 sq. meters

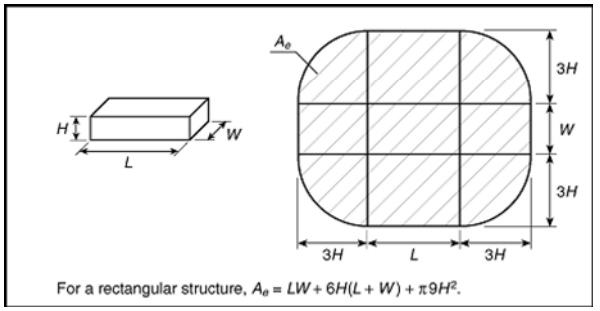
Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$	1
Isolated structure on a hilltop	2

Assume

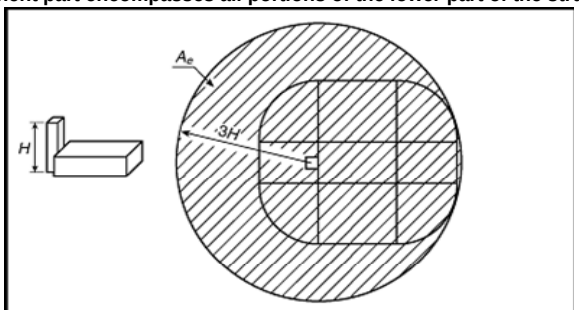
0.50

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

Assume **1.0**

C_2 — Structural Coefficients			
	Roof		
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

= input required

APPENDIX C – Determination of Wildfire Hazard Severity

Using NFPA 1144

WILDLAND FIRE RISK AND HAZARD SEVERITY ASSESSMENT FORM
Appendix A, Figure A.4.2 from NFPA 1144

ELEMENT	POINTS
A. Means of Access	
1. Ingress and egress	
a. Two or more roads in/out	**0**√
b. One road in/out	7
2. Road width	
a. >= 24 ft	0
b. >= 20 ft and < 24 ft	**2**√
c. < 20 ft	4
3. All-season road condition	
a. Surfaced road, grade <5%	**0**√
b. Surfaced road, grade > 5%	2
c. Non-surface road, grade < 5%	2
d. Non-surface road, grade > 5%	5
e. Other than all-season	7
4. Fire Service Access	
a. <= 300 ft with turnaround	**0**√
b. > 300 ft with turnaround	2
c. < 300 ft with no turnaround	4
d. >= 300 ft with no turnaround	5
5. Street Signs	
a. Present	**0**√
b. Not present	5
B. Vegetation (Fuel Models)	
1. Characteristics of predominate vegetation within 300 ft.	
a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
2. Defensible space	
a. More than 100 ft of vegetation treatment from the structures	1
b. 71 ft to 100 ft of vegetation treatment from the structures	3
c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
d. < 30 ft of vegetation treatment from the structures	25

C. Topography Within 300 of Structures

1.	Slope < 9%	**1**√
2.	Slope 10% to 20 %	4
3.	Slope 21% to 30%	7
4.	Slope 31% to 40%	8
5.	Slope > 41%	10

D. Additional Rating Factors

1.	Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2.	Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3.	Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4.	Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1.	Class A roof	**0**√ (underground structure)
2.	Class B roof	3
3.	Class C roof	15
4.	Nonrated	25

F. Building Construction

1.	Materials		
	a.	Noncombustible/fire-resistive siding, eaves, and deck	**0**
	b.	Noncombustible/fire-resistive siding and combustible deck	5
	c.	Combustible siding and deck	10
2.	Building setback relative to slopes of 30% or more		
	a.	>= 30 ft to slope	1√
	b.	< 30 ft to slope	5

G. Available Fire Protection

1.	Water source availability			
	a.	Pressurized water source availability		
		500 gpm hydrants <= 930ft apart	**0**√	
		250 gpm hydrants <= 930ft apart	1	
	b.	Nonpressurized water source availability		
		>= 250 gpm continuous for 2 hours		3
		< 250 gpm continuous for 2 hours		5
	c.	Water unavailable		10
2.	Organized response resources			
	a.	Station <= 5 miles from structure		**1**√

	b. Station > 5 miles from structure	3
3.	Fixed fire protection	
	a. NFPA 13	**0**
	b. None	5√
H.	**Placement of Gas and Electric Utilities**	
1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5
I.	**Total**	**30**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 30 = A **LOW** Hazard